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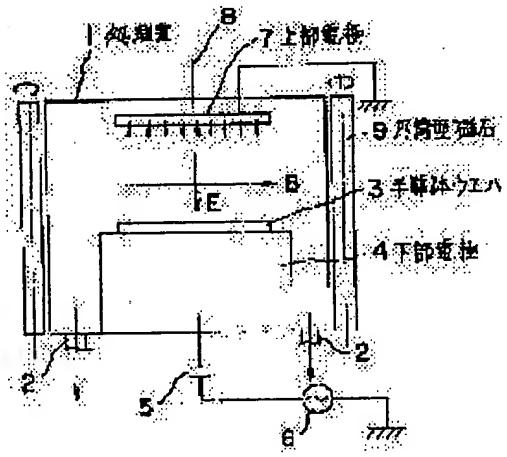
(54) MAGNETRON TYPE PLASMA PROCESSING DEVICE

(57)Abstract:

PURPOSE: To provide a magnetron type plasma processing device in which space saving can be realized and also cost reduction can be achieved by making compact a permanent magnet and its driving mechanism.

CONSTITUTION: When a semiconductor wafer 3 is processed by plasma, while a horizontal magnetic field is applied to this semiconductor wafer 3 horizontally arranged in a processing chamber 1, 12 pieces of rod-like cylindrical magnets 9 are so provided upright as to make pairs in a point symmetry state in the circumference of the processing chamber 1. At the same time, those respective cylindrical magnets 9 are synchronously rotatably linked to a motor through a gear train.



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CLAIMS

[Claim(s)]
[Claim 1] while accomplishing a pair to point symmetry and setting up two or more cylindrical magnets to it around above-mentioned processing room in the magnetron mold plasma treatment equipment which carries out plasma treatment of this processed object, respectively, impressing a magnetic field horizontal to the processed object arrang at a level with the processing interior of a room -- each of these cylindrical magnets -- a synchronization -- the magnetron mold plasma treatment equipment characterized by connecting with a drive pivotable.
[Claim 2] Magnetron mold plasma treatment equipment according to claim 1 characterized by dividing each above-mentioned cylindrical magnet into two up and down, respectively.
[Claim 3] Magnetron mold plasma treatment equipment according to claim 1 or 2 characterized by setting the magne field strength of the cylindrical magnet of above-mentioned two or more pairs as 50-1000 gauss.
[Claim 4] Magnetron mold plasma treatment equipment of any one publication of claim 1 characterized by setting th rotational speed of the above-mentioned cylindrical magnet as 5 - 60rpm - claim 3.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to magnetron mold plasma treatment equipment.
[0002]
[Description of the Prior Art] In case a semiconductor device is made, micro processing of the semi-conductor wafer carried out using the etching system which used the plasma from the former, and wiring structure is formed. Howeve the hyperfine structure of a half micron and quarter micron order is needed with high integration of the latest semiconductor device. Therefore, the plasma of high density is made under a higher vacuum ambient atmosphere, th damage by the plasma is lessened as much as possible, and the etching system which uses the plasma effectively as much as possible is variously developed from the former. For example, reactive-ion-etching (RIE) equipment and a magnetron mold RIE system are known as such an etching system.
[0003] An RIE system generates the plasma of etching gas between the lower electrode which impressed high-frequency power, and the grounded up electrode, irradiates the reactant ion in this plasma towards the lower electrod by which the auto-bias was carried out to negative, and it is constituted so that the etched component of processed bo surfaces, such as a semi-conductor wafer, may be etched with this reactant ion. However, if it becomes the micro-machining of quarter micron level, the mean free path of active species, such as reactant ion, is short, and since perpendicular micro processing becomes difficult under the effect by dispersion of reactant ion, it is necessary to ma it a high vacuum further and to control dispersion of ion in an RIE system. So, the magnetron mold RIE system is us for such micro-machining. This magnetron mold RIE system impresses a magnetic field more nearly horizontal to th electric field which make the plasma under a high vacuum ambient atmosphere, and are formed for example, in the vertical direction in this plasma than the case of an RIE system, and it is constituted so that densification of the plasm may be carried out using cycloid movement of the electron by this rectangular electromagnetic field. However, the plasma tends to incline toward a part by electronic cycloid movement in this case, and the uniform plasma cannot as whole necessarily be acquired. therefore, the electromagnetism from the former -- he makes a rotation magnetic field using a coil or a permanent magnet, and is trying to equalize the plasma In the case of an electromagnet, the current passed in two or more coils is changed, and a rotation magnetic field is made, and in the case of a permanent magnet he rotates a permanent magnet mechanically, and is trying to make a rotation magnetic field. Especially in the case o the latter, for example, a ring-like permanent magnet is arranged so that a processing room may be surrounded, and t thing it was made to rotate this ring-like permanent magnet mechanically is known.
[0004]
[Problem(s) to be Solved by the Invention] However, in the case of the conventional magnetron mold plasma treatme equipment made to rotate a ring-like permanent magnet, since the permanent magnet itself was a heavy lift, the technical problem that the drive which carries out the rotation drive of the supporting structure which supports such ring-like permanent magnet, or the ring-like permanent magnet becomes large-scale structurally, and such occupancy area also became large and moreover became cost quantity occurred.
[0005] This invention was made in order to solve the above-mentioned technical problem, realizes space-saving-izat by miniaturizing a permanent magnet and its drive, and aims at offering the magnetron mold plasma treatment equipment which can attain cost reduction.
[0006]
[Means for Solving the Problem] while the magnetron mold plasma treatment equipment of this invention according claim 1 accomplishes a pair to point symmetry and sets up two or more cylindrical magnets to it around the above-mentioned processing room in the magnetron mold plasma treatment equipment which carries out plasma treatment this processed object, respectively, impressing a magnetic field horizontal to the processed object arranged at a level with the processing interior of a room -- each of these cylindrical magnets -- a synchronization -- it connects with a drive pivotable and is constituted.

[0007] Moreover, in invention according to claim 1, the magnetron mold plasma treatment equipment of this inventi according to claim 2 divides each above-mentioned cylindrical magnet two up and down, respectively, and is constituted.
[0008] Moreover, in invention according to claim 1 or 2, the magnetron mold plasma treatment equipment of this invention according to claim 3 sets the magnetic field strength of the cylindrical magnet of above-mentioned two or more pairs as 50-1000 gauss, and is constituted.
[0009] Moreover, in invention of any one publication of claim 1 - claim 3, the magnetron mold plasma treatment equipment of this invention according to claim 4 sets the rotational speed of the above-mentioned cylindrical magne 5 - 60rpm, and is constituted.
[0010]
[Function] After arranging on a processed object at a level with the processing interior of a room, while generating th plasma in the processing interior of a room according to invention of this invention according to claim 1 Although th magnetron plasma will be formed in the processing interior of a room by this magnetic field and plasma treatment w be performed to a processed object according to an operation of this magnetron plasma if a magnetic field parallel to processed object is impressed to the processing interior of a room from two or more pairs of cylindrical magnets Und the present circumstances, if a drive is made to drive, each cylindrical magnet connected with this can carry out synchronous rotation, respectively, the level magnetic field of the processing interior of a room can rotate with each this cylindrical magnet that carries out synchronous rotation, and the local bias of the magnetron plasma can be equalized by this rotation level magnetic field.
[0011] Moreover, according to invention of this invention according to claim 2, in invention according to claim 1, si each above-mentioned cylindrical magnet was divided into two up and down, respectively, a rotation level magnetic field can be formed according to an individual by the upper and lower sides of the processing interior of a room with two steps of up-and-down cylindrical magnets, and the magnetron plasma can be further equalized to an up-and-dow rotation level magnetic field.
[0012] Moreover, according to invention of this invention according to claim 3, in invention according to claim 1 or since the magnetic field strength of the cylindrical magnet of above-mentioned two or more pairs was set as 50-1000 gauss, the suitable magnetron plasma can be acquired to the plasma treatment of a processed object.
[0013] Moreover, according to invention of this invention according to claim 4, in invention of any one publication o claim 1 - claim 3, since the above-mentioned cylindrical magnet was set as the rotational speed of 5 - 60rpm, all cylindrical magnets can be rotated smoothly and the suitable magnetron plasma can be acquired to the plasma treatm of a processed object.
[0014]
[Example] This invention is explained referring to the magnetron mold plasma etching system (a "magnetron RIE system" is called hereafter) shown in drawing 1 - drawing 6 hereafter. As shown in drawing 1 , the magnetron RIE system of this example was formed in the shape of a cylinder with conductive ingredients, such as aluminum, and is equipped with the processing room 1. This processing room 1 is constituted so that it may be constituted by the airtig structure, and vacuum suction may be carried out with the vacuum pump which is not illustrated through the exhaust pipe 2 connected to that peripheral surface lower part, for example, the vacuum ambient atmosphere of 10 to 2 or les Torrs can be formed. And the susceptor (it is also called a "susceptor" if needed) 4 which serves as the lower electrod which lays the semi-conductor wafer 3 with conductive ingredients, such as aluminum, is arranged in the base in this processing room 1, and it is constituted so that the semi-conductor wafer 3 may be held by the electrostatic chuck (no shown) attached on this lower electrode 4. And the cooler style which uses refrigerants, such as liquefaction nitrogen built in the interior of this susceptor 4, and it is constituted so that a susceptor 4 may be cooled to the temperature of minus field by this cooler style. Furthermore, RF generator 6 is connected to this susceptor 4, i.e., a lower electrode, through a blocking capacitor 5, and it is constituted so that the high-frequency voltage of 13.56MHz may be impress to the lower electrode 4 through a blocking capacitor 5 from this RF generator 6. Moreover, the up electrode 7 forme in the flat hollow discoid which separates spacing of 15-20mm and counters is arranged above the lower electrode 4, and this up electrode 7 is grounded so that ground potential may be maintained. And the supply pipe 8 which penetra the center of processing room 1 top face in the center of a top face of this up electrode 7, and is open for free passage the source of supply (not shown) of etching gas is attached, and it is constituted so that the etching gas supplied from this supply pipe 8 may be equally spouted into [whole] the processing room 1 through the up electrode 7.
[0015] Moreover, in this example, as the cylindrical magnet 9 formed with the permanent magnet shows drawing 2 , the perimeter perimeter of the processing room 1 is covered, hoop direction regular intervals are separated, and two o more 12 are arranged, for example. And across the processing room 1, 12 cylindrical magnets 9 accomplish a pair to point symmetry, are arranged, and they are constituted so that the parallel level magnetic field B may be impressed t the semi-conductor wafer 3 on a horizontal direction 4, i.e., a susceptor, in the processing room 1 with these cylindri m gnets 9. In ddition, dr wing 2 h s omitted nd shown five front cylindric l m gnets 9. And s shown in dr wing

and drawing 4 , the cylinder space 11 to which each cylindrical magnet 9 was made to correspond is formed in the peripheral wall 10 of the processing room 1, and the cylindrical magnet 9 is contained in such cylinder space 11, respectively. A shaft is attached in the vertical edge of each cylindrical magnet 9, respectively, and the cylindrical magnet 9 is supported to revolve free [rotation] in the cylinder space 11 of a peripheral wall 10 with these shafts. Moreover, the gearing 13 is attached in the shaft 12 of the lower limit of each cylindrical magnet 9, respectively. Moreover, the major-diameter gearing 14 of the shape of a ring formed in the magnitude of the processing room 1 which balanced that outer diameter below a little was arranged, inside this major-diameter gearing 14, it continued a the perimeter, internal-tooth 14A was formed, and it has geared with the gearing 13 of cylindrical magnet 9 lower lim by this internal-tooth 14A. Furthermore, as shown in drawing 4 , the motor 15 is arranged between the gearing 13 of some one cylindrical magnets 9 and 9, and 13, and the gearing 17 fixed to the revolving shaft 16 of this motor 15 meshes to the major-diameter gearing's 14 internal-tooth 14A like the gearing 13 of the cylindrical magnet 9.
[0016] Therefore, the gearing 17 of a motor 15 transmits the turning effort of a motor to all the gearings 13 through t major-diameter gearing 14, and he does synchronous rotation of all the cylindrical magnets 9 in this direction (clockwise rotation), respectively, and thereby, he is constituted so that the level magnetic field B in the processing room 1 may be gradually rotated in the direction of a continuous-line arrow head to a broken-line arrow head, as sho in drawing 3 . And the drive of the cylindrical magnet 9 will be constituted from this example by a motor 15 and the gear trains 17, 14, and 13. In addition, synchronous rotation of all the cylindrical magnets 9 can be carried out like th case where it mentions above even if it connected the revolving shaft of a motor 15 with one cylindrical magnet 9 directly.
[0017] As for the reinforcement of the level magnetic field impressed with all the cylindrical magnets 9, it is desirab to set it as 50-1000 gauss, and it is more desirable to set it as 100-700 gauss. If this magnetic field strength becomes difficult to get about the magnetron effectiveness in less than 50 gauss and it exceeds 1000 gauss, it becomes cost quantity, and it is uneconomical and it is not [the magnet itself cannot acquire the magnetron effectiveness corresponding to it, and] desirable. Although especially the ingredient of the permanent magnet used for this cylindrical magnet 9 is not restricted, alloy magnets, such as a Fe-Cr-Co system, a ferrite magnet, etc. are used preferably, for example. Moreover, as for the rotational speed of the cylindrical magnet 9, it is desirable to set it as 5 60rpm, and it is more desirable to set it as 15 - 25rpm. Less than five rpm of rotation of the level magnetic field B is enough as this rotational speed, and equalization of a plasma consistency is difficult, and it becomes [even if it exce 60rpm, cannot expect equalization beyond it, but / wear of each gearings 17, 14, and 13 of the gear train] intense moreover and is not desirable.
[0018] Moreover, as shown in drawing 5 , even if it constitutes the rolling mechanism of the cylindrical magnet 9, it can expect the same operation effectiveness as what is shown in drawing 3 and drawing 4 . That is, the cylindrical magnet 9 shown in drawing 5 is constituted like what was shown in drawing 3 and drawing 4 except differing in a rotation drive. Then, only a rotation drive is explained. In this case, as shown in this drawing, sprockets 18 and 18 ar attached in the lower limit of the shaft 12 of each cylindrical magnet 9 at two places of the upper and lower sides, an chain 19 is wound between the sprocket 18 of the ****** cylindrical magnets 9 and 9, and 18, and it is constituted s that each cylindrical magnet 9 may synchronize, respectively and may rotate through each chain 19. And as shown in drawing 5 , one more sprocket 20 is attached in the lower limit of the shaft 12 of one cylindrical magnet 9. Moreover motor 21 is arranged in the outside of this sprocket 20, and it is attached in the sprocket 23 at revolving-shaft 22 upp limit of this motor 21. And a chain 24 is wound around the sprocket 23 of this motor 21, and the sprocket 20 of the cylindrical magnet 9, and it is constituted so that the turning effort of a motor 21 may be transmitted to the cylindrica magnet 9 through this chain 24. Therefore, by carrying out a rotation drive clockwise, as a motor 21 shows in this drawing, this cylindrical magnet 9 is constituted so that it may rotate to a clockwise rotation too through a sprocket 2 a chain 24, and a sprocket 20. The remaining cylindrical magnets 9 are constituted so that synchronous rotation may carried out to a clockwise rotation as mentioned above through one cylindrical magnet 9 connected with the motor 2 respectively.
[0019] Next, actuation is explained. The semi-conductor wafer 3 is laid in the lower electrode 4 in the processing roo 1 by which vacuum suction was carried out, and the semi-conductor wafer 3 is held on the lower electrode 4 accordi to the Coulomb force of an electrostatic chuck. Subsequently, the etching gas from a supply pipe 8 is supplied into th processing room 1 through the up electrode 7, and the gas pressure of etching gas is set as the degree of vacuum of 1 to 2 or less Torrs. Then, the plasma will be generated, if the high-frequency voltage of 13.56MHz is impressed to the lower electrode 4 from RF generator 6 and vacuum discharge is carried out between the lower electrode 4 and the up electrode 7 through etching gas. At this time, since it is far light as compared with reactant ion and a radical, the electron in the plasma flows into the lower electrode 4 preferentially, and thereby, the auto-bias of the lower electrod is carried out to negative through a blocking capacitor 5. The potential difference arises between the auto-bias potent of this lower electrode 4, and plasma potential, and the electric field E of the vertical direction are formed among the both ccording to this potenti l difference. Since 12 cylindric l m gnets 9 ccomplish p ir nd re rr nged round

the processing room 1 on the other hand at point symmetry, The 600 gauss level magnetic field B is impressed in the processing room 1 with all these cylindrical magnets 9. The electric field E formed in the vertical direction and this level magnetic field B cross at right angles, and forms rectangular electromagnetic field. The electron in the plasma carries out cycloid movement near the lower electrode 4 according to an operation of rectangular electromagnetic fie active species is further activated for the reactant ion in the plasma etc., and the densification magnetron plasma is generated.

[0020] A motor 15 drives at this time, and since that turning effort is passed through and transmitted through that gearing 17, the major-diameter gearing 14, and a gearing 13, all the cylindrical magnets 9 are carrying out synchrono rotation to the clockwise rotation. Since it is rotating with the rotational speed of for example, 20rpm to the arrow-he location shown with the broken line from the arrow-head location shown as the continuous line as the whole level magnetic field B in the processing room 1 shows drawing 3 by synchronous rotation of all the cylindrical magnets 9, the magnetron plasma which the direction of electronic cycloid movement also changes with this rotation, equalizes plasma in the processing room 1 uniformly, and has a uniform plasma consistency generates. Therefore, the reactant ion in the plasma equalizes in the processing room 1, uniform ion irradiation is performed all over semi-conductor wafer 3 on the lower electrode 4, and plasma treatment, such as uniform reactive ion etching, can be performed all ov semi-conductor wafer 3.

[0021] On the other hand, since the permanent magnet which impresses the level magnetic field B surrounded the perimeter of the processing room 1 not with the structure which surrounds the perimeter of the processing room 1 wi a ring-like permanent magnet like before but with 12 cylindrical magnets 9, the load with which the weight of all the cylindrical magnets 9 becomes quite lightweight as compared with a ring-like permanent magnet, and only a part to have lightweight-ized requires it for the gear trains 13, 14, and 17 and a motor 15 is mitigable.

[0022] since 12 cylindrical magnets 9 constituted the permanent magnet which impresses the level magnetic field B according to this example as explained above, as compared with the former, the load which can make [compact] a permanent magnet lightweight, has it as compared with the conventional ring-like permanent magnet, and is applied the motor 15 and the gear trains 13, 14, and 17 as a drive is boiled markedly, and-izing of it can be carried out [lightweight]. Therefore, on the whole, the cylindrical magnet 9, a motor 15, and the gear trains 13, 14, and 17 can miniaturized, the installation tooth spaces of the whole equipment can be reduced, and reduction of installation cost c be aimed at. Moreover, by fluctuating the number of the cylindrical magnet 9 if needed, level magnetic field strength can be changed suitably and the degree of freedom on the setup can be obtained. Moreover, since the suitable magnetron plasma for plasma treatment could be easily acquired since the level magnetic field strength in the processing room 1 impressed with 12 cylindrical magnets 9 was set as 50-1000 gauss according to this example, and the synchronous rotational speed of each cylindrical magnet 9 was set as 5 - 60rpm, if too much burden is hung on a motor 15, the uniform magnetron plasma [be / nothing] can be acquired easily.

[0023] Moreover, the cylindrical magnet 9 used for this invention may be divided into two by the upper and lower sides, as shown in drawing 6 . In this case, for example like the above-mentioned example, the little cylindrical magnets 9A and 9B of a pair can be connected by the coupling rod 25, respectively, and others can constitute them from the upper and lower sides like each above-mentioned example. Thus, a level magnetic field is formed according an individual by the upper and lower sides by constituting each cylindrical magnet 9 with the little cylindrical magne 9A and 9B of respectively the upper and lower sides, and while reinforcement falls, by the interaction of an up-and-down level magnetic field, the level magnetic field B of the whole impressed in the processing room 1 can form the a a whole much more uniform level magnetic field B, and can raise the homogeneity of plasma treatment further.

[0024] In addition, although the above-mentioned example explained the structure which embedded the cylindrical magnet 9 in the cylinder space 11 formed in the peripheral wall 10 of the processing room 1, it cannot be overemphasized that a cylindrical magnet may be arranged in the perimeter of a processing room through supporter material. Moreover, that the drive which drives the cylindrical magnet 9 should just be a device in which the synchronous rotation of the cylindrical magnet 9 can be made to carry out in the same direction, the transfer device i which the driving force of a motor is transmitted transmits the turning effort of a motor to all cylindrical magnets wi an epicyclic gear besides the gear trains 13, 14, and 17 or a chain, and sprocket mechanism, a pulley, a belt, etc. of th above-mentioned example, and may be made to carry out synchronous rotation of these. Moreover, if this invention magnetron mold plasma treatment equipment, it is widely applicable also about a CVD system besides an etching system.

[0025]

[Effect of the Invention] as explained above, while according to invention of this invention according to claim 1 accomplishing a pair around the above-mentioned processing room and setting up two or more cylindrical magnets t point symmetry -- each of these cylindrical magnets -- a synchronization -- since it connected with the drive pivotabl by miniaturizing a permanent magnet and its drive, space-saving-ization can be realized and the magnetron mold pl sm tre tment equipment which c n tt in cost reduction c n be offered.

[0026] Moreover, according to invention of this invention according to claim 2, the magnetron mold plasma which c impress a much more uniform level magnetic field to claim 1 at the processing interior of a room, and can perform much more uniform plasma treatment to a processed object at it since each cylindrical magnet was divided into two u and down in invention at the publication, respectively can be offered.
[0027] Moreover, according to invention given in claim claim 3 of this invention, since the magnetic field strength o the cylindrical magnet of above-mentioned two or more pairs was set as the publication in invention at 50-1000 gaus at claim 1 or claim 2, the magnetron mold plasma which can acquire the suitable magnetron plasma for plasma treatment easily can be offered.
[0028] Moreover, according to invention given in claim claim 3 of this invention, since the rotational speed of the above-mentioned cylindrical magnet was set as the publication in invention at 5 - 60rpm any one of claim 1 - the cla 3, if too much burden is hung on a drive, the magnetron mold plasma which can acquire the uniform magnetron plas [be / nothing] easily can be offered.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the sectional view showing the configuration of one example of the magnetron mold plasma treatm equipment of this invention.
[Drawing 2] It is the perspective view showing notionally the relation of the magnetic field and semi-conductor wafe which are impressed with the cylindrical magnet of the magnetron mold plasma treatment equipment shown in draw 1.
[Drawing 3] It is the top view showing the relation of the cylindrical magnet of magnetron mold plasma treatment equipment and drive which are shown in drawing 1.
[Drawing 4] It is the important section sectional view showing the relation of the cylindrical magnet of magnetron m plasma treatment equipment and drive which are shown in drawing 1.
[Drawing 5] It is the shown sectional view equivalent to drawing 4 which shows other examples of the magnetron m plasma treatment equipment of this invention.
[Drawing 6] It is a sectional view equivalent to drawing 1 which shows the configuration of the example of further others of the magnetron mold plasma treatment equipment of this invention.
[Description of Notations]
1 Processing Room
3 Semi-conductor Wafer (Processed Object)
4 Lower Electrode
7 Up Electrode
9 Cylindrical Magnet
9A Little cylindrical magnet (one of the cylindrical magnets divided into two)
9B Little cylindrical magnet (one of the cylindrical magnets divided into two)
13 Gearing (Drive)
14 Major-Diameter Gearing (Drive)
15 Motor (Drive)
17 Gearing (Drive)

[Translation done.]